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SPRAY FLAMMABILITY TEMPERATURE OF SHIPBOARD  
FUELS AND LUBRICANTS

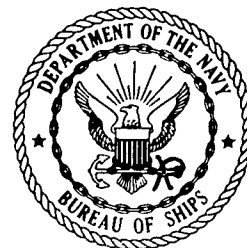
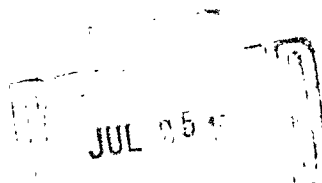
Final Report NBTL Project A-410

9 July 1963

by

R. D. NORTON

**NAVAL BOILER AND TURBINE LABORATORY**  
**PHILADELPHIA NAVAL SHIPYARD**  
**PHILADELPHIA 12, PENNA.**



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ABSTRACT

This investigation indicates that oil soaked steam pipe installation is a fire hazard. Nominal data on ignition temperature of shipboard fuels and lubricants are not applicable for this situation.

The phenomenon observed is that spontaneous ignition of the oil soaked installation at temperatures in the 500 to 600 degree range results from the temperature of the pipe and the presence of oxygen and oil.

Ways and means for preventing this hazardous condition are evaluated and it is concluded that commercial coatings are available to prevent oil penetration of the installation. However, before the problem is completely solved specifications for the purchase of coatings and practical methods for their shipboard application must be developed and evaluated.

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SUMMARY PAGE

The Problem

What is the lowest temperature at which shipboard fuels and lubricants will ignite? Establish the cause of shipboard fires originating from this source.

Findings

The spray flammability temperature of JP-5 fuel and Navy Special fuel oil as obtained by the NBTL Spray Flammability Furnace is not conclusive.

Two different temperatures can be obtained with both fuels which shows that if the conditions are slightly changed the ignition temperatures will vary. Results indicate that these fuels will flash at a temperature lower than that obtained with the furnace. A study of oil soaked lagging shows that lagging on a steam line presents a potential fire hazard when soaked with lubricating oil. Since there is no substitute material for steam pipe lagging, a coating material impervious to oil can be used to prevent lagging from becoming oil contaminated.

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ADMINISTRATIVE INFORMATION

Spray flammability testing of JP-5 fuel and Navy Special fuel oil was authorized by Bureau of Ship's letters 10340 Ser 634A-498 of 29 Nov 1961 and 634A-285 of 2 Jul 1962. Costs of project were charged to Allotment 290/RDT&EN 62,2421.

The Subproject Number is SRO01-06-02, Task 0600.

REPORT OF INVESTIGATION

Introduction

The spray flammability of Navy Special fuel oil and JP-5 fuel depends upon the environmental conditions which prevail at the time the fuel spray comes in contact with a hot surface. The particle size of the spray and air-spray mixture as well as the temperature of the hot surface will determine the temperature at which the fuels ignite.

Temperatures obtained for Navy Special and JP-5 fuels with the Naval Boiler and Turbine Laboratory spray flammability furnace did not appear to be the minimum temperature at which these fuels will ignite. All attempts to reproduce the environmental conditions which can cause flammability by spraying fuels were unsuccessful. Different temperatures could be obtained for the same fuel, indicating that ignition will not always occur when the sprayed fuel comes in contact with a hot surface of high temperature.

A study of oil soaked steam pipe lagging shows it to be a fire hazard. When the lagging becomes soaked with lubricating oil or Navy Special fuel there is an oxidation, aided by the heat in the steam line, which causes the oil to reach its burning temperature. This may take place over a period of several hours or in a shorter time depending upon the conditions adjacent to the oil soaked section and the speed of oxidation of the particular oil.

Should oil soaked steam pipe lagging start burning and spray from a broken line carrying a flammable liquid come in contact with the

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burning oil you will have a potential fire. Surrounding conditions and size of spray particles will determine if a fire will occur.

Many samples of steam lagging material which were products of different manufacturers were taken from Navy supply and tested. They were tested to determine if all had the same oil burning characteristics when soaked with lubricating oil.

The manufacturers of steam pipe insulation material have been consulted concerning the modification of the content of lagging as to the possibility of eliminating any product that might contribute to oxidation or cracking oils. They feel that any alteration would destroy the insulation properties of the lagging material and suggest that some type of coating which is impervious to oil be used.

Description of Test Set Up

The NBTL spray flammability furnace was used with some modifications in an attempt to establish the lowest ignition temperatures for JP-5 and Navy Grade fuel oil. A 2 inch steam pipe coupling with thermocouple attached was placed in the furnace. This furnished a hot metal surface for the spray to hit. A small jet of air was introduced to give a better spray-oxygen mixture. The furnace method was considered inconclusive since more than one value could be obtained. It is believed that a true spray flammability temperature of these fuels cannot be determined unless fireroom conditions can be produced, such as exists when a fire occurs on board ship.

Figure 1 gives a diagram of the test set up for studying the behavior of oil soaked steam lagging. A piece of lagging material  $1\frac{1}{2} \times 3/4 \times 3/4$  inches in size was soaked with 2190 TEP oil and placed

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in a temperature controlled muffle furnace. The specimen was placed on a wire gauze supported on a tripod so that it would not be in contact with the heated surface of the furnace and be exposed to air on all sides. A thermocouple (#1) was imbedded in the specimen and another thermocouple (#2) was suspended  $\frac{1}{4}$  inch directly above #1 and both connected to recorders. The furnace was set for 500 F to insure that the furnace heat would not exceed that temperature. The furnace door was left open for the duration of the test; therefore, the average temperature of the furnace was below 500 F. The temperature of the air adjacent to the specimen was recorded with the #2 thermocouple.

A test set up, as shown in Figure 2, was erected to further determine if conditions can be obtained which will give a spray flammability temperature for JP-5. The set up consisted of a 3 inch pipe with electric glow-bar for heating. A thermocouple was attached to the pipe and connected to a controller so that the temperature of the pipe could be controlled. The temperature was raised to a maximum of 900 F and a fine mist of JP-5 was sprayed onto the hot pipe with spray brush.

The same pipe was lagged with lagging that had lubricating oil poured onto it. The temperature was raised to 900 F to determine if the conditions were such that the oil would start burning.

Discussion and Results

The spray flammability furnace gave more than one ignition temperature for JP-5 fuel and similar results for Navy Special. The Ignition values were 790 F and 890 F for JP-5 and 705 F and 810 F for Navy Special.

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Since results obtained with NBTL spray flammability furnace were inconclusive and surrounding conditions that could cause a flame could not be obtained, a study of oil soaked lagging was pursued. Fireroom observations led to an investigation of steam pipe lagging that has been soaked with lubricating oil. It is general knowledge that when the lagging on a high temperature steam line becomes soaked with fuel oil the oil sometimes ignites.

The lagging on board ship sometimes becomes soaked with lubricating oil due to oil line leaks and the oil drops onto the steam line. It is believed that this oil goes through an oxidation process, aided by heat from steam line, and the ignition temperature is reached. Figure 3 shows the results obtained when the oil soaked lagging is tested with set up shown in Figure 1. These results are representative for all test runs. The time may be longer before glowing starts but both 2190 TEP and Navy Special fuel oil give the same type of curve. Time can be influenced by the speed of oxidation and can be shortened by increasing the temperature. The thermocouple suspended in the air just above the specimen shows several degrees below that of the furnace setting due to having the door open during test. As soon as the oil becomes ignited, due to radiated heat from the burning oil, the suspended thermocouple shows an increase in temperature. Should an oil soaked section of lagging ignite and start glowing and the spray from a broken Diesel oil or JP-5 fuel line come in contact with it, a fire can start if conditions are right.

Many specimens of lagging were tested and practically all gave the same results. Two or three insulating materials showed no burning but a slight increase in temperature. The insulating properties of these

were destroyed entirely and were no more useful for insulation purposes.

Appendix I gives an illustration of how oil soaked lagging can ignite at a lower temperature than that obtained with the spray flammability furnace which was 690-740 F.

There are a number of products on the market for protective coatings for insulation materials and some of these were investigated. Four manufacturers submitted samples of their products for evaluation. The first prerequisite for a satisfactory coating is that it must be impervious to oil. The reason for the coating is to prevent the lagging from absorbing oil that may come in contact with it and thereby avoid a chance for fire.

The coating materials were first tested for their ability to protect lagging from oil. This was done by coating  $\frac{2}{3}$  of the area of a block of insulation,  $1\frac{1}{2} \times 2 \times 6$  inches, and allowing it to dry for several hours and then immersing the coated end in a beaker containing oil for approximately 48 hours. The coating was cut away and examined for oil seepage. The only cases where any oil appeared was due to small pin holes that coating did not cover. Most of these coating materials were manufactured to withstand a service temperature of 180 F at the coated surface. These coatings were subjected to a temperature of 180-185 F for approximately 3 days and then tested for oil penetration and temperature increase did not affect their resistance to oil. Figure 4 gives an evaluation of the coating materials studied.

It will be noted that one of the coating products contains a volatile flammable solvent. Although it is a very good coating material the solvent with a flash point of 100 F renders it a fire hazard. All coatings that use water as solvent for clean-up is the most desirable and only two of the seven tested require organic solvents for clean-up. The product with designation O-I-C forms a very hard coating which is oil repellent, and not pliable, but surface is not easily broken. If it can be made more flexible, it should be a very good coating material.

The temperature of these materials were heated above 300 F and there was a tendency for all to shrink and in several cases the surface cracked. Since specifications require that steam lines be lagged for 125 to 130 F outside surface temperature, it appears that all of these coatings given in Figure 4 have sufficient temperature margin.

#### Conclusions

It is concluded that:

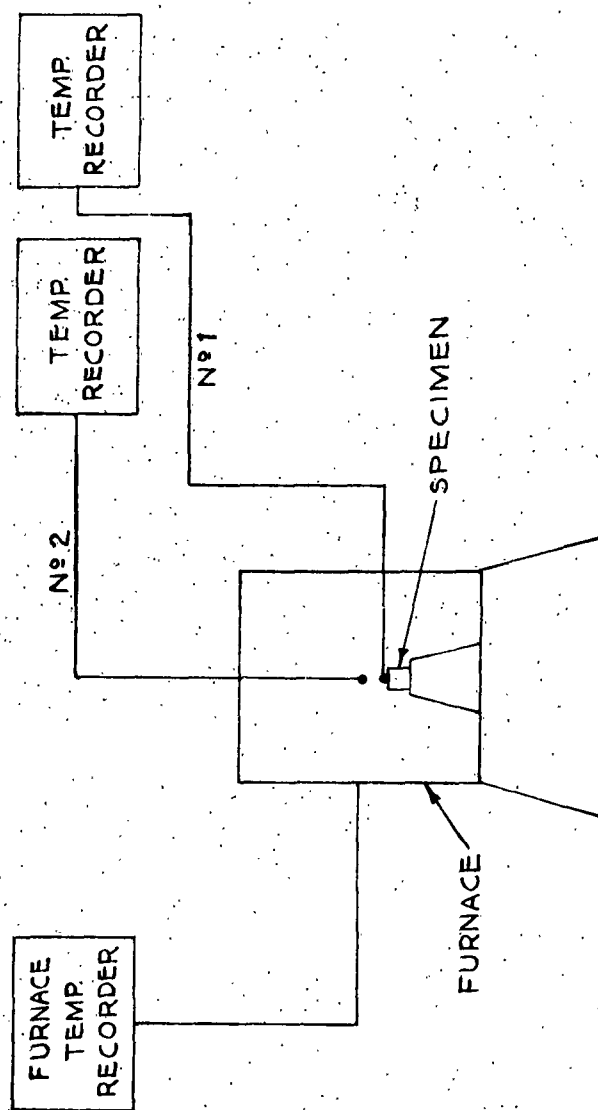
- (1) The spray flammability temperature of JP-5 and Navy Special fuel oil when determined with the NBTL furnace is not conclusive because surrounding conditions cannot be controlled.
- (2) Spray flammability temperature of a fuel depends upon the surrounding conditions as well as the surface temperature of the object upon which the spray hits.
- (3) Steam lagging that has become saturated with lubricating oil will slowly oxidize with the aid of heat from the steam line and reach ignition temperature and start glowing thereby presenting a fire hazard.

(4) A coating can be applied to steam lagging that is exposed to oil contamination and prevent the lagging from becoming oil soaked.

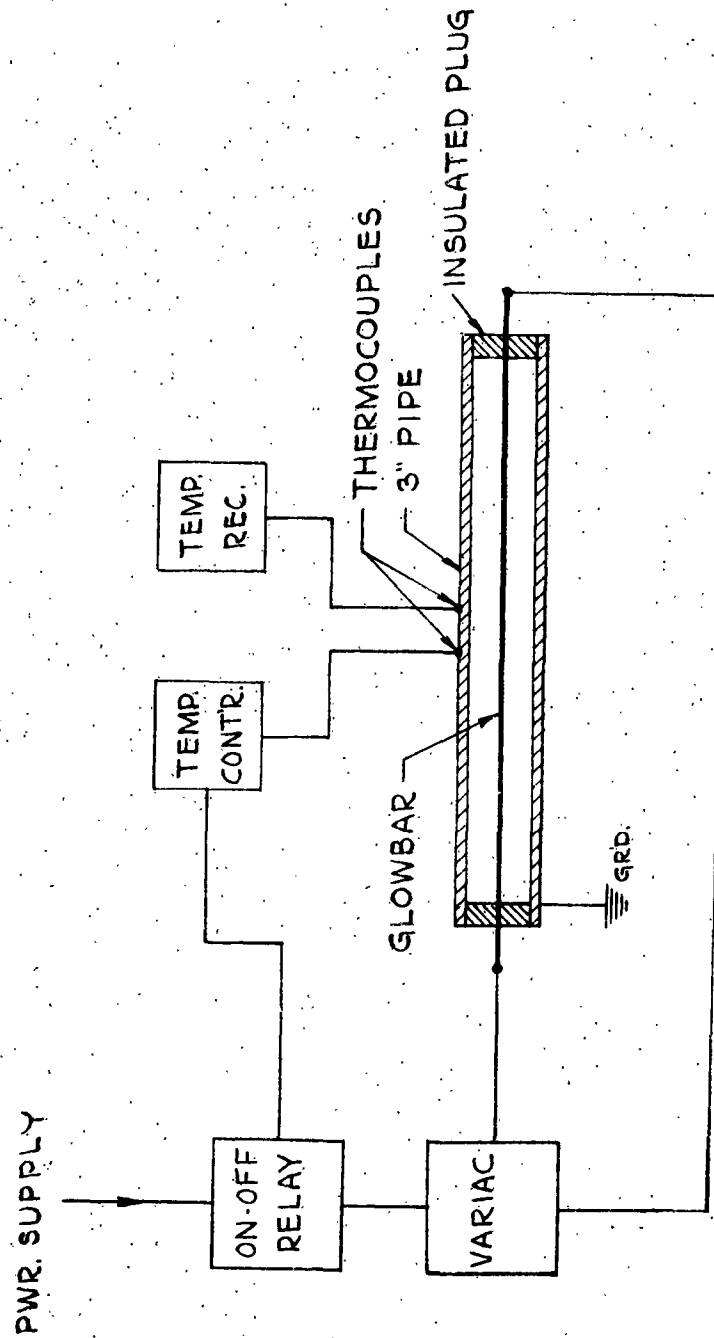
Recommendations

It is recommended that coatings be applied on steam lagging wherever the possibility of oil contamination exists. Whenever the original lagging must be disturbed for repairs on board ship, it is recommended that after the lagging is replaced a coating be used to prevent oil being absorbed should it come in contact with the steam line.

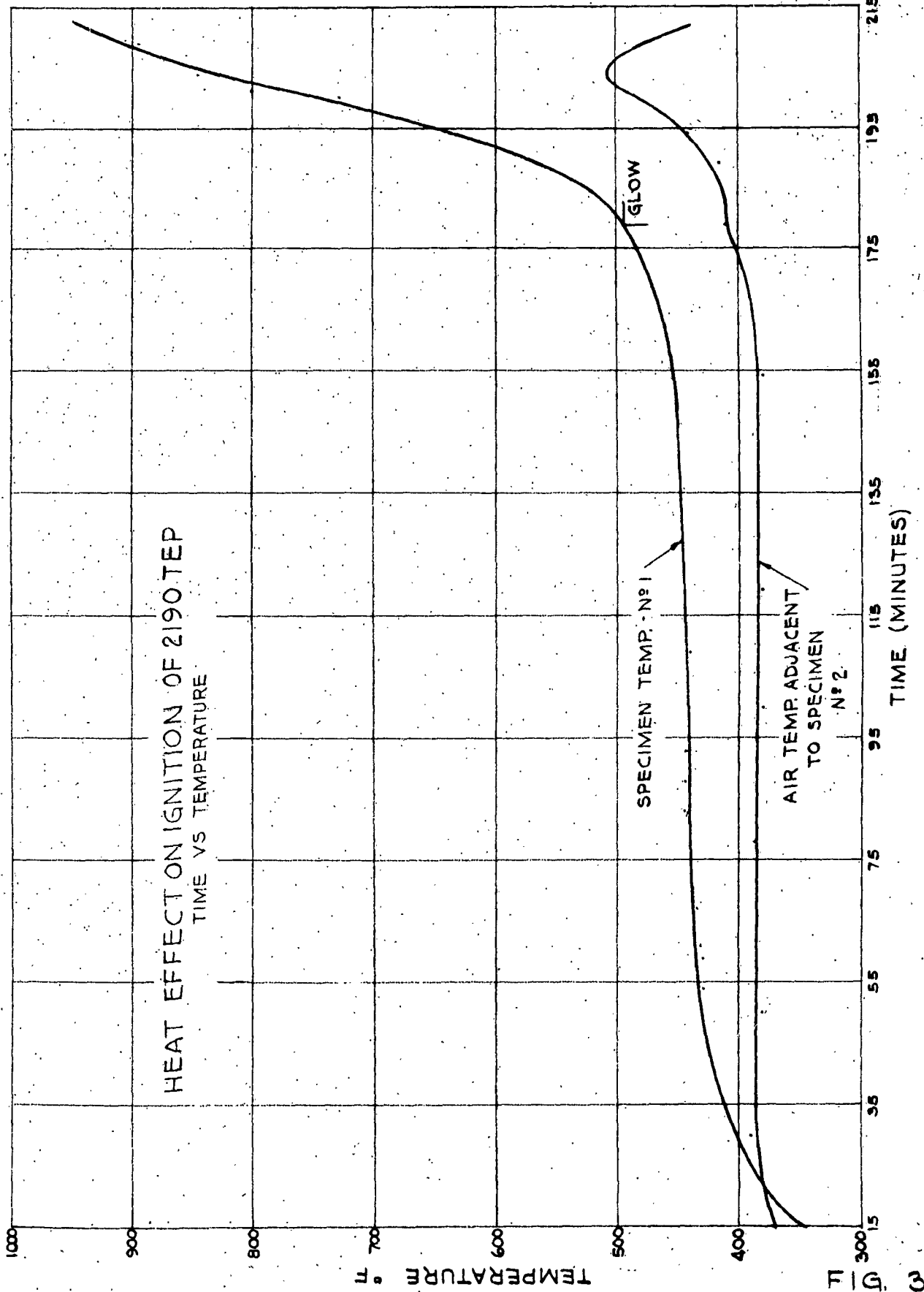
It is further recommended that work on development of specifications and methods of shipboard application of coatings be authorized.



SCHEMATIC DIAGRAM  
OF  
TEST SET-UP



SCHEMATIC DIAGRAM  
for  
SPRAY FLAMMABILITY SET-UP



PROPERTIES OF COATING MATERIALS FOR STEAM LAGGING

| <u>Company</u>            | <u>Company Designation</u> | <u>Resistance to Oil</u> | <u>Viscosity</u> | <u>Application</u>     | <u>Service Temp. at Coated Surface</u> | <u>Pliability</u> | <u>Solvent for Clean Up</u> |
|---------------------------|----------------------------|--------------------------|------------------|------------------------|--|-------------------|-----------------------------|
| Benjamin Foster Company   | 39-99                      | Yes                      | Paste            | Rubber Glove or Trowel | 185 F                                  | Pliable           | Water                       |
| Benjamin Foster Company   | 41-99                      | Yes                      | Paste            | Rubber Glove or Trowel | 185 F                                  | Pliable           | Water                       |
| Benjamin Foster Company   | Hypolastic*                | Yes                      | Paste            | Rubber Glove or Trowel | Above 200 F                            | Pliable           | Xylol                       |
| Flintkote Company         | Type 11                    | Yes                      | Paste            | Rubber Glove or Trowel | 185 F                                  | Pliable           | Water                       |
| Flintkote Company         | M 11                       | Yes                      | Paste            | Rubber Glove or Trowel | Tacky at 175 F                         | Pliable           | Toluene                     |
| Insul-Coustic Corporation | IC-551                     | Yes                      | Paste            | Rubber Glove or Trowel | 185 F                                  | Pliable           | Water                       |
| In-Chem Company           | O-I-C                      | Yes                      | Paste            | Rubber Glove or Trowel | 185 F                                  | Hard**            | Water                       |

\*Contains Volatile Flammable Solvent with flash point of 100°F  
 \*\*Very tough to break

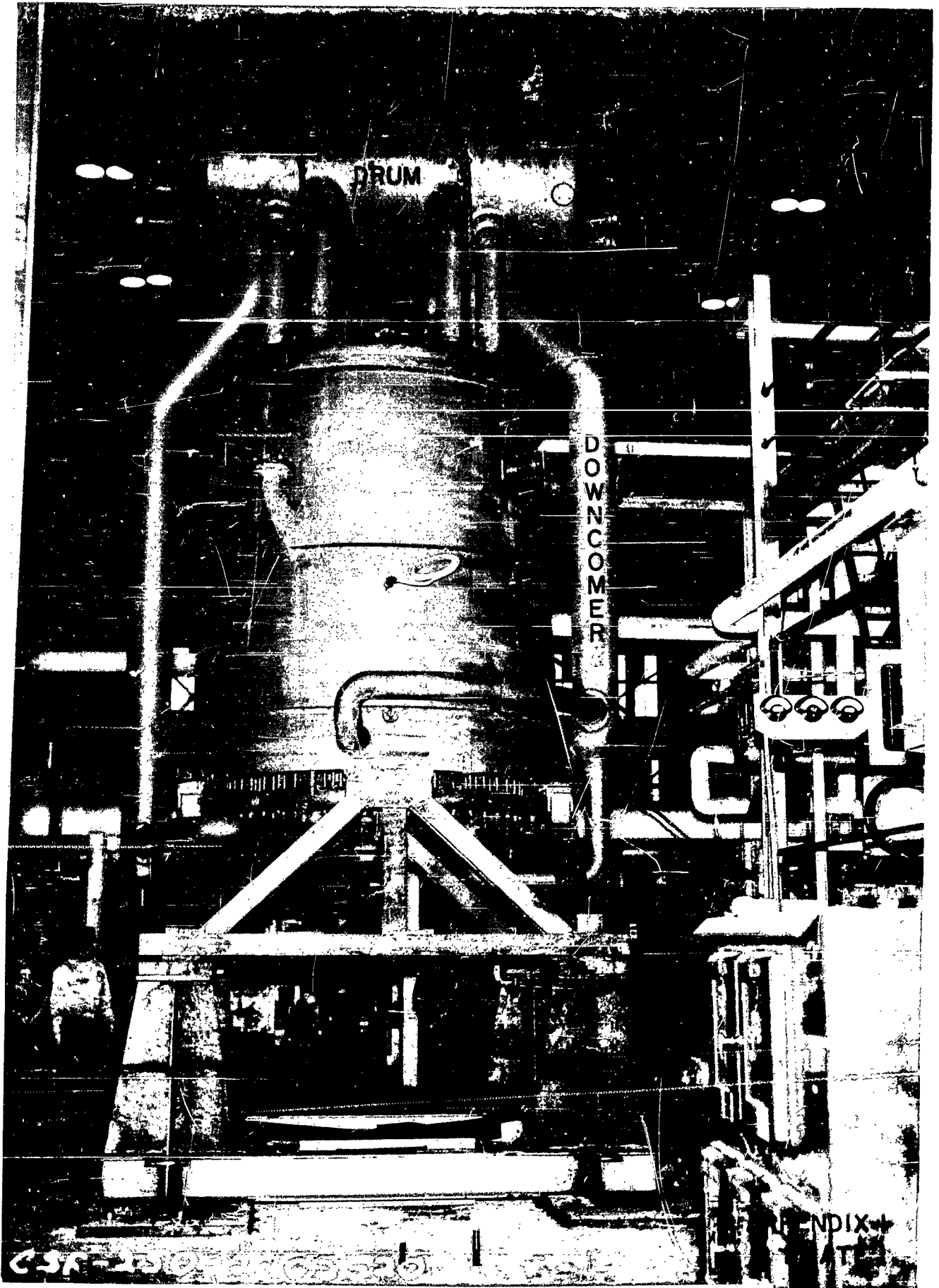
Figure 4

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APPENDIX I

Oil soaked lagging as a fire hazard is illustrated by a fire which occurred on an NBTL boiler test stand. The boiler is a pressure fired boiler shown without lagging, (Plate I). The downcomer line, as indicated, was lagged at the time of the fire.

Due to an accident during the repair of an oil pump in the vicinity of the line, the lagging became soaked with lubricating oil. This happened approximately 40 hours before light-off and had ample time for the lagging to soak up the oil. The boiler was operated 6 hours and secured for approximately 18 hours before the next light-off after which there were two hours of operation. The fire occurred just after the boiler was secured after the 2 hour operation. The temperature of this line does not exceed 570 F. In this case there was ample oil after reaching the autogenous temperature to furnish sufficient vapors to burst into flame.



|  |  |
|--|--|
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